

001

1 WHAT IS CLAIMED IS:

1 1. A method comprising contacting at least an alkane having from 2 to 4 carbon atoms
2 to a catalyst comprising at least nickel oxide and dehydrogenating said alkane with a selectivity
3 of greater than 70% and a conversion of greater than 10%.

1 2. The method of claim 1 wherein said selectivity is greater than 75%.

1 3. The method of claim 2 wherein said selectivity is greater than 80%.

1 4. The method of claim 3 wherein said selectivity is greater than 85%.

1 5. The method of claim 1 wherein said conversion is greater than 15%.

1 6. A process for the oxidative dehydrogenation of an alkane having from 2 to 4 carbon
2 atoms comprising contacting said alkane in the presence of oxygen to a compound comprising
3 nickel oxide and obtaining a selectivity in said dehydrogenation of greater than 70% and a
4 conversion of greater than 10%.

1 7. The method of claim 6 wherein said selectivity is greater than 75%.

1 8. The method of claim 7 wherein said selectivity is greater than 80%.

1 9. The method of claim 8 wherein said selectivity is greater than 85%.

1 10. The method of claim 6 wherein said conversion is greater than 15%.

1 11. A process for the oxidative dehydrogenation of an alkane having from 2 to 4 carbon
2 atoms comprising
3 contacting a gas mixture comprising said alkane and oxygen to a nickel oxide containing
4 catalyst; and
5 obtaining a selectivity greater than 70% and a conversion greater than 10%.

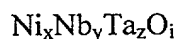
1 12. The method of claim 11 wherein said selectivity is greater than 75%.

1 13. The method of claim 12 wherein said selectivity is greater than 80%.

1 14. The method of claim 13 wherein said selectivity is greater than 85%.

1 15. The method of claim 11 wherein said conversion is greater than 15%.

1 16. A method for the oxidative dehydrogenation of an alkane having from 2 to 4 carbon
2 atoms comprising contacting said alkane in the presence of oxygen to a material having the
3 empirical formula



5 wherein x is in the range of about 0.05-0.96, y is in the range of from about 0-0.8, z is in
6 the range of from 0-0.8 and i is a number that satisfies valence requirements; and the sum of y
7 and z is at least 0.1.

1 17. The method of claim 16, wherein x is in the range of from about 0.4 to 0.96.

1 18. The method of claim 16 wherein x is greater than 0.5.

1 19. The method of claim 16 wherein y and z are each greater than zero and wherein the
2 sum of y and z is smaller than 0.6.

1 20. A method for the oxidative dehydrogenation of an alkane having from 2 to 4 carbon
2 atoms comprising contacting said alkane in the presence of oxygen to a material having the
3 empirical formula



5 wherein Ni is nickel and x is in the range of about 0.05-0.96;

6 A is a metal selected from the group consisting of Co, Nb, Ta and combinations thereof
7 and j is in the range of from about 0-0.8;

8 B is a dopant selected from the group consisting of Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba,
9 Mn, La, Ce, Pr, Nd, Sm and combinations thereof and k is in the range of from 0-0.5;

10 C is a dopant selected from the group consisting of Sn, Al, Fe, Si, B, Sb, Tl, In, Ge, Cr,
11 Pb and combinations thereof and l is in the range of from 0-0.5

i is a number that satisfies the valence requirements of the other elements present; and
the sum of j, k and l is at least 0.1.

21. The method of claim 20, wherein x is in the range of from about 0.5 to 0.85.

22. The method of claim 20 wherein x is greater than 0.1.

23. The method of claim 20 wherein j, k and l are each greater than zero and wherein the
sum of j, k and l is smaller than 0.8.

24. A method of making a C₂-C₄ olefin comprising the step of contacting a gas mixture
with a catalyst having an empirical formula:



wherein *b*, *c* and *d* are numbers greater than or equal to zero, but less than one, and at
least one of *b*, *c* and *d* is nonzero;

e and *f* are numbers greater than or equal to zero, but less than or equal to 0.35;

g and *h* are numbers greater than or equal to zero, but less than or equal to 0.10;

a is a number greater than zero, but less than one, and satisfies:

$$a \leq 1 - b - c - d - e - f - g - h;$$

i is a number that satisfies valence requirements; and

the gas mixture comprises a C₂-C₄ alkane and oxygen.

25. The method of claim 24, wherein:

c is greater than or equal to 0.10, but less than or equal to 0.85; and

b, *d*, *e*, *f*, *g*, and *h* equal zero.

26. The method of claim 25, wherein *c* is greater than or equal to 0.12, but less than or
equal to 0.42.

27. The method of claim 26, wherein *c* is greater than or equal to 0.14, but less than or
equal to 0.25.

1 28. The method of claim 25, wherein c is greater than or equal to 0.20, but less than or
2 equal to 0.50.

1 29. The method of claim 28, wherein c is greater than or equal to 0.31, but less than or
2 equal to 0.41.

1 30. The method of claim 24, wherein:
2 d is greater than or equal to 0.10, but less than or equal to 0.60; and
3 b, c, e, f, g , and h equal zero.

1 31. The method of claim 30, wherein d is greater than or equal to 0.19, but less than or
2 equal to 0.50.

1 32. The method of claim 30, wherein d is greater than or equal to 0.14, but less than or
2 equal to 0.25.

1 33. The method of claim 24, wherein:
2 b is greater than or equal to 0, but less than or equal to 0.20;
3 c is greater than or equal to 0, but less than or equal to 0.80; and
4 d, e, f, g and h equal zero.

1 34. The method of claim 33, wherein b is greater than or equal to 0.001, but less than or
2 equal to 0.20; and c is greater than or equal to 0.02, but less than or equal to 0.56.

1 35. The method of claim 33, wherein b is greater than or equal to 0, but less than or equal
2 to 0.30; and c is greater than or equal to 0, but less than or equal to 0.45.

1 36. The method of claim 35, wherein a is greater than or equal to 0.55, but less than or
2 equal to 0.85.

1 37. The method of claim 33, wherein:
2 b is greater than or equal to 0, but less than or equal to 0.33; and
3 c is greater than or equal to 0, but less than or equal to 0.52.

1 38. The method of claim 37, wherein:

2 b is less than or equal to 0.10; and

3 c is greater than or equal to 0.20, but less than or equal to 0.50.

1 39. The method of claim 37, wherein:

2 b is less than or equal to 0.03; and

3 c is less than or equal to 0.50.

1 40. The method of claim 39, wherein c is greater than or equal to 0.15, but less than or
2 equal to 0.26.

1 41. The method of claim 37, wherein:

2 b is greater than or equal to 0.001, but less than or equal to 0.19; and

3 c is greater than or equal to 0.13, but less than or equal to 0.33.

1 42. The method of claim 41, wherein c is less than or equal to 0.23.

1 43. The method of claim 24, wherein:

2 c is greater than or equal to 0, but less than or equal to 0.50;

3 d is greater than or equal to 0, but less than or equal to 0.50; and

4 b, e, f, g and h equal zero.

1 44. The method of claim 43, wherein:

2 c is greater than or equal to 0.03, but less than or equal to 0.40; and

3 d is greater than or equal to 0.02, but less than or equal to 0.29.

1 45. The method of claim 43, wherein:

2 a is greater than or equal to 0.46, but less than or equal to 0.96;

3 c is greater than or equal to 0.04, but less than or equal to 0.44; and

4 d is greater than or equal to 0.04, but less than or equal to 0.44.

1 46. The method of claim 45, wherein:

2 a is greater than or equal to 0.54, but less than or equal to 0.72;

3 c is greater than or equal to 0.04, but less than or equal to 0.38; and
4 d is greater than or equal to 0.04, but less than or equal to 0.40.

1 47. The method of claim 46, wherein:

2 a is less than or equal to 0.65;
3 c is less than or equal to 0.20; and
4 d is greater than or equal to 0.15.

1 48. The method of claim 24, wherein:

2 c , d and e are each greater than or equal to 0, but less than or equal to 0.35; and
3 b , f , g and h equal zero.

1 49. The method of claim 24, wherein:

2 c , d and f are each greater than or equal to 0, but less than or equal to 0.35; and
3 b , e , g and h equal zero.

1 50. The method of claim 46, wherein:

2 a is greater than or equal to 0.58, but less than or equal to 0.64;
3 c is greater than or equal to 0.06, but less than or equal to 0.38;
4 d is greater than or equal to 0.04, but less than or equal to 0.30; and
5 f is less than or equal to 0.26.

1 51. The method of claim 47, wherein:

2 a is greater than or equal to 0.55, but less than or equal to 0.65;
3 c is greater than or equal to 0.30, but less than or equal to 0.40; and
4 b , d , e , and f equal zero.

1 52. The method of claim 51, wherein:

2 a is greater than or equal to 0.58, but less than or equal to 0.61;
3 c is greater than or equal to 0.35, but less than or equal to 0.36;
4 g is greater than or equal to 0, but less than or equal to 0.05; and
5 h is greater than or equal to 0, but less than or equal to 0.07.

1 53. The method of claim 24, wherein the gas mixture further comprises a material
2 selected from the group consisting of ethylene, butylenes or raffinate II.

1 54. The method of claim 24, wherein said contacting is carried out at a temperature of
2 about 400°C or less.

1 55. The method of claim 24, wherein the contacting step is carried out at a temperature of
2 about 325°C or less.

1 56. The method of claim 24, wherein the contacting step is carried out at a temperature of
2 about 300°C or less.

1 57. The method of claim 24, wherein said catalyst is not supported on a carrier.

1 58. The method of claim 24, wherein said catalyst is supported on a carrier selected from
2 the group consisting of silica, alumina, titania, zirconia, magnesia, zeolites, clays and
3 combinations thereof.

1 59. The method of claim 24 wherein said contacting is carried out for a time in the range
2 of from about 100 milliseconds to about 10 seconds.

1 60. The method of claim 24, wherein said gas mixture comprises oxygen in the range of
2 from about 0.01-20% by volume and ethane in the range of from about 10-99.99% by volume.

1 61. The method of claim 60, wherein said gas mixture further comprises diluents in the
2 range of from about 0.01-60% by volume.

1 62. The method of claim 60, wherein said reaction pressure is in the range of from 0.5 to
2 20 bar.

1 63. The method of claim 24, wherein said catalyst is diluted with a binder or inert filler.

1 64. The method of claim 24 wherein said catalyst is calcined at a temperature of 400°C or
2 less.

1 65. The method of claim 24 wherein said catalyst is calcined at a temperature of 350°C or
2 less.

1 66. The method of claim 24 wherein said catalyst is calcined at a temperature of 300°C or
2 less.

1 67. A method for the oxidative dehydrogenation of ethane to ethylene, optionally with
2 ethylene as a co-feed with said ethane, comprising contacting ethane to a catalyst comprising
3 nickel oxide (NiO) with either niobium oxide (Nb₂O₅) or tantalum oxide (Ta₂O₅).